

Limits to the Exponential Advances in DWDM Filter Technology?

DARPA/MTO WDM for Military Platforms

April 18-19, 2000

McLean, VA

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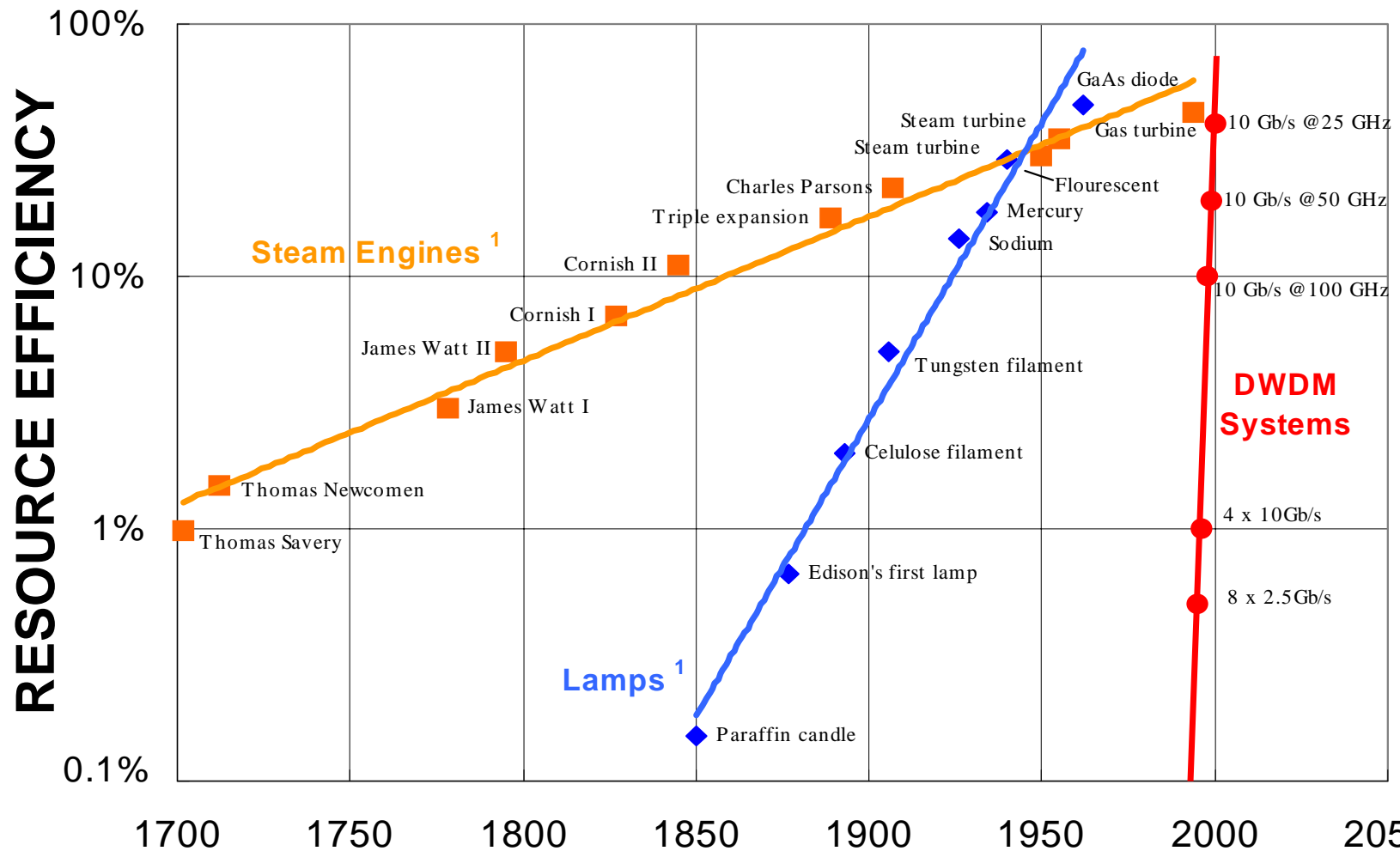
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Limits to the Exponential Advances in DWDM Filter Technology?

DARPA/MTO WDM for Military Platforms

- Progress in DWDM Filtering Technology
 - Thin Film Filters
 - Arrayed Waveguide Gratings
 - Holographic Gratings
- Interleaver Status
- Roadmap for the Near Future

TECHNOLOGY PROGRESS



1) Jesse H. Ausubel, "Where is Energy Going?", The Industrial Physicist, Vol. 6 (1), p. 17 (Feb. 2000).

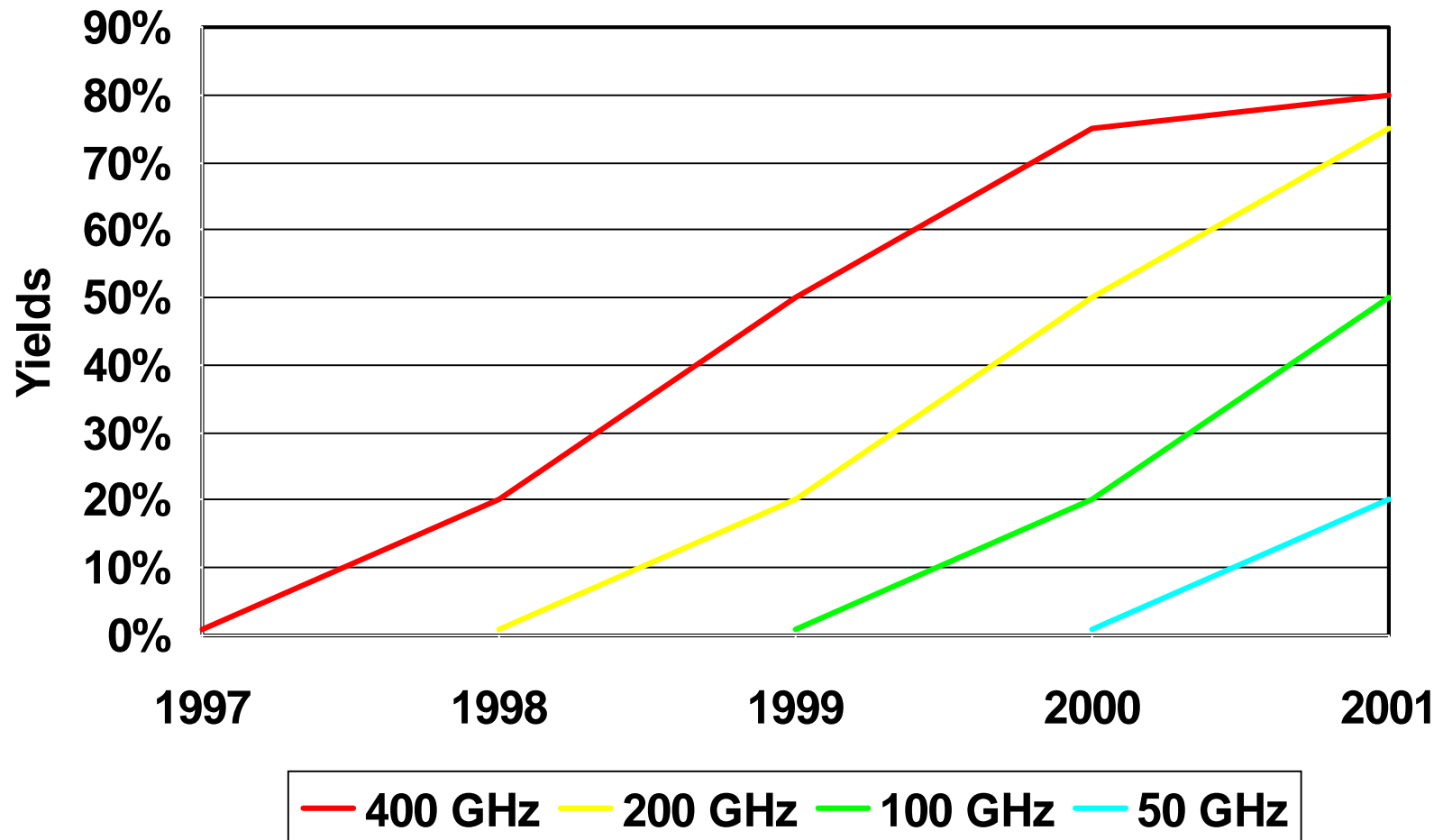
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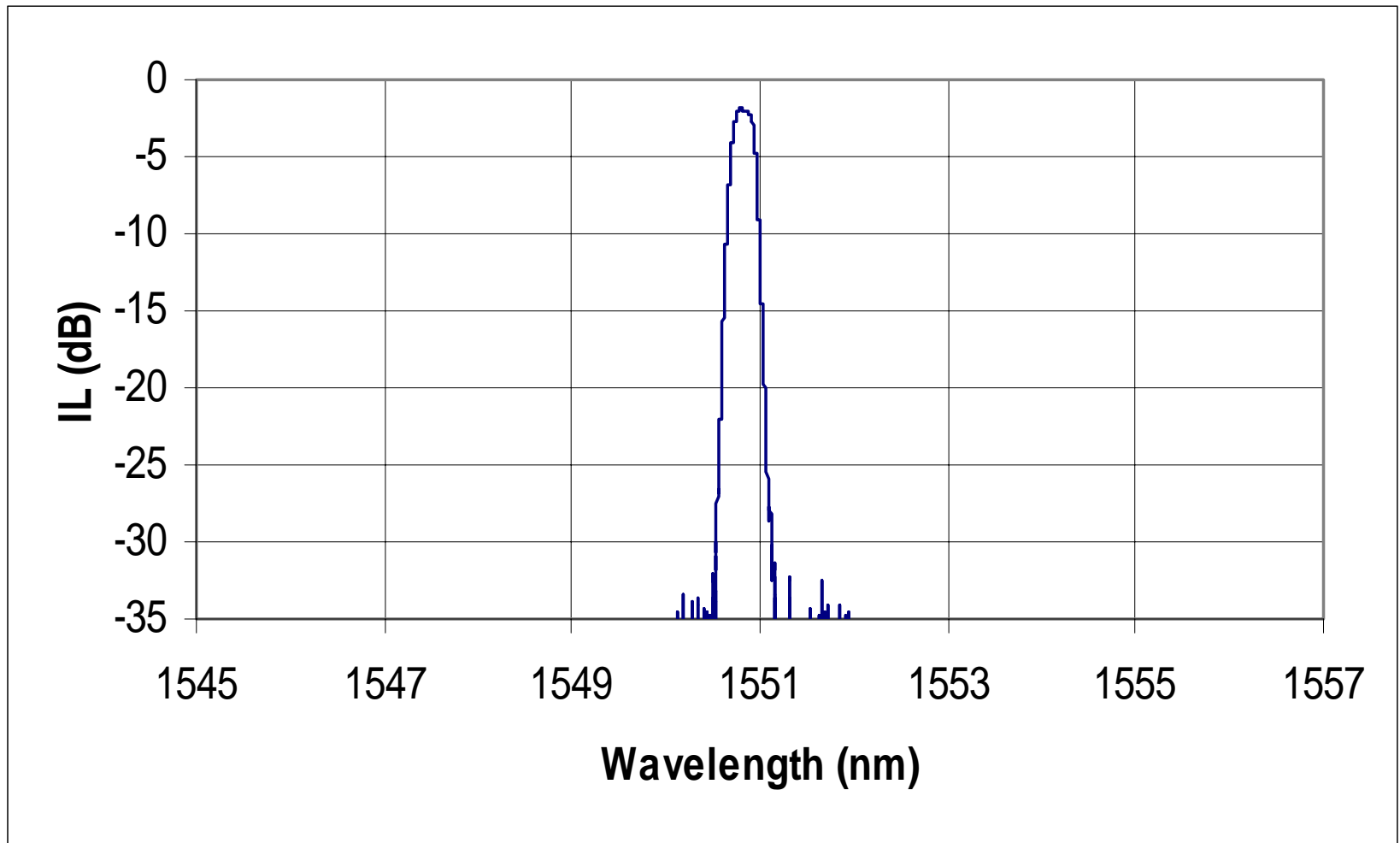
Industry Filter Yield Improvements



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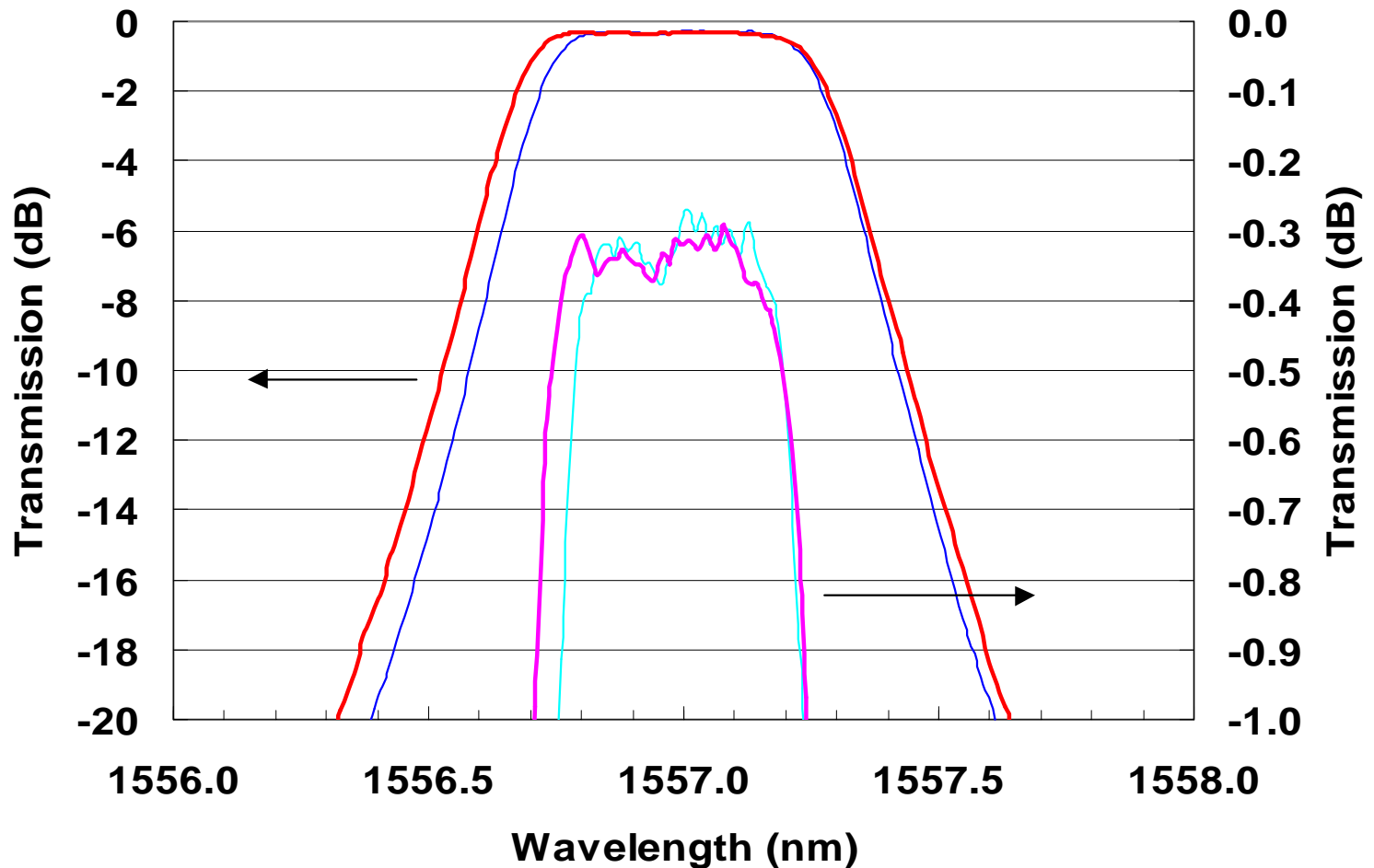
50GHz DWDM Spectrum-Transmission



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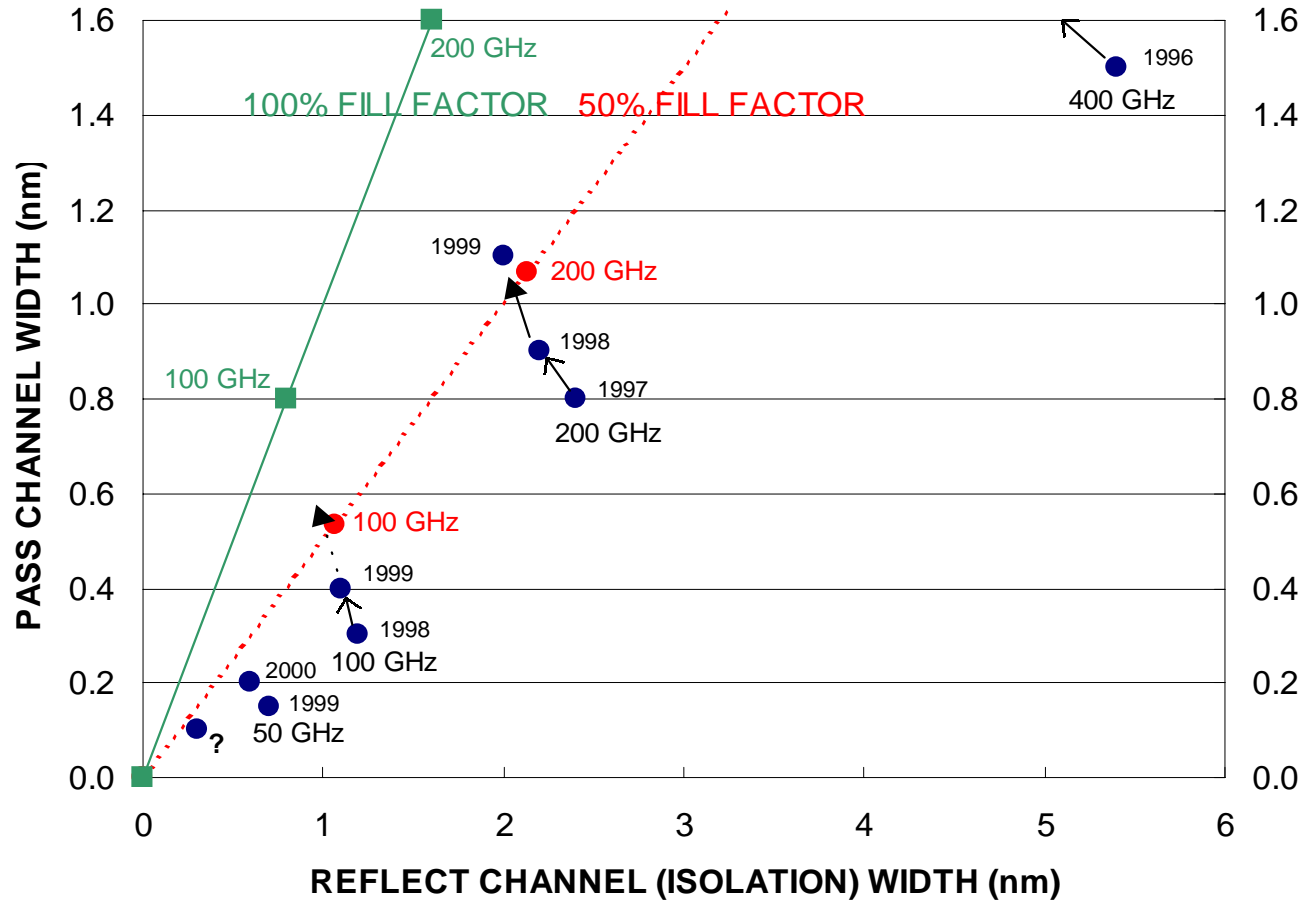
100 GHz Filter Shapes



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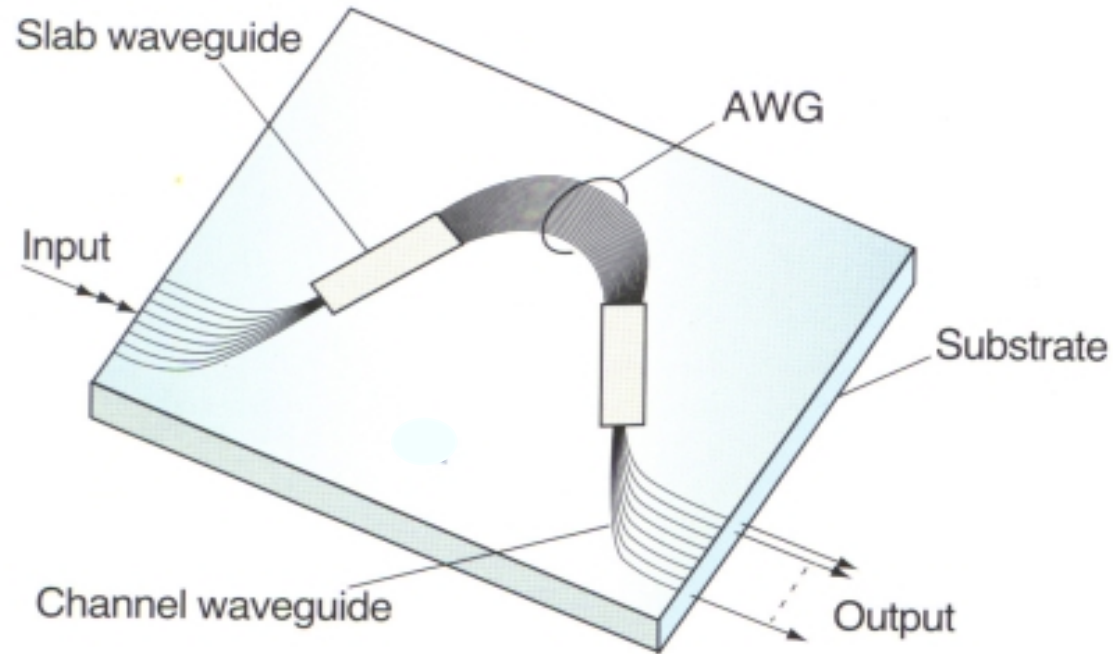
DWDM THIN FILM FILTER PROGRESS



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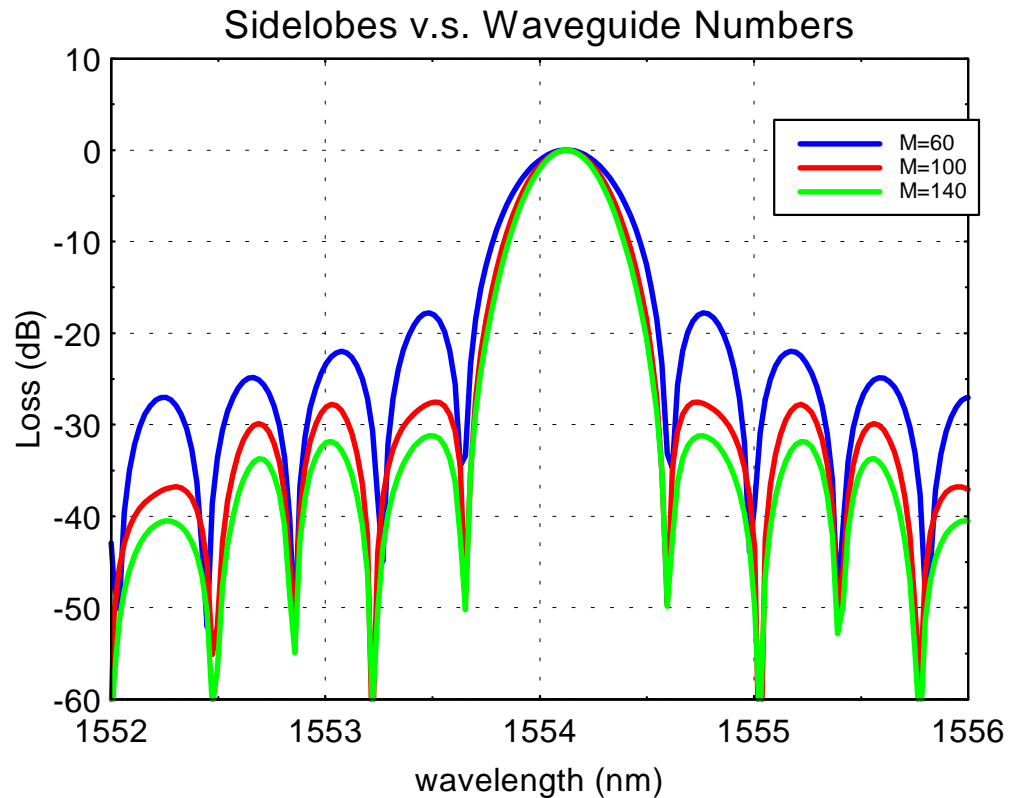


AWG DWDM MUX & DEMUX



Waveguide pattern of AWG multi/demultiplexer chip

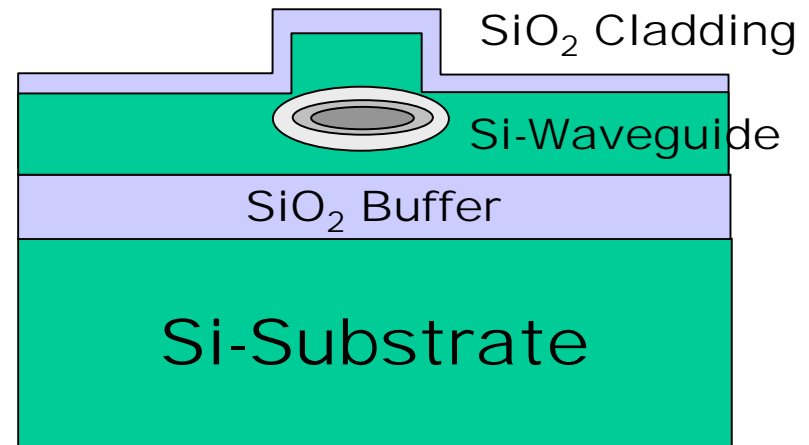
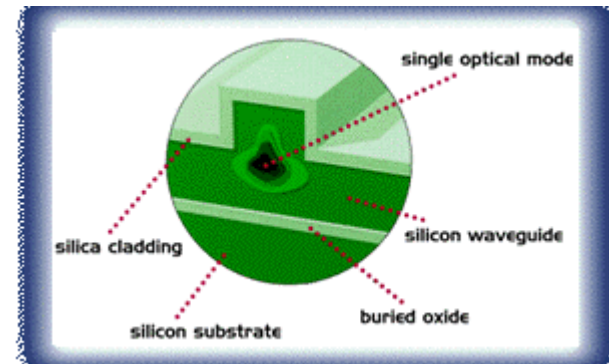
Basic Performance of an AWG



Basic Waveguide Structure

Silicon-on-Silicon (Bookham Technology)

- easier to manufacture, Si-CMOS process
- pure semiconductor waveguide, small bending radius, small chip size
- difficult to package due to mode miss-match
- few vendors, little R&D
- offer lowest X-Talk
- further integration, OEIC

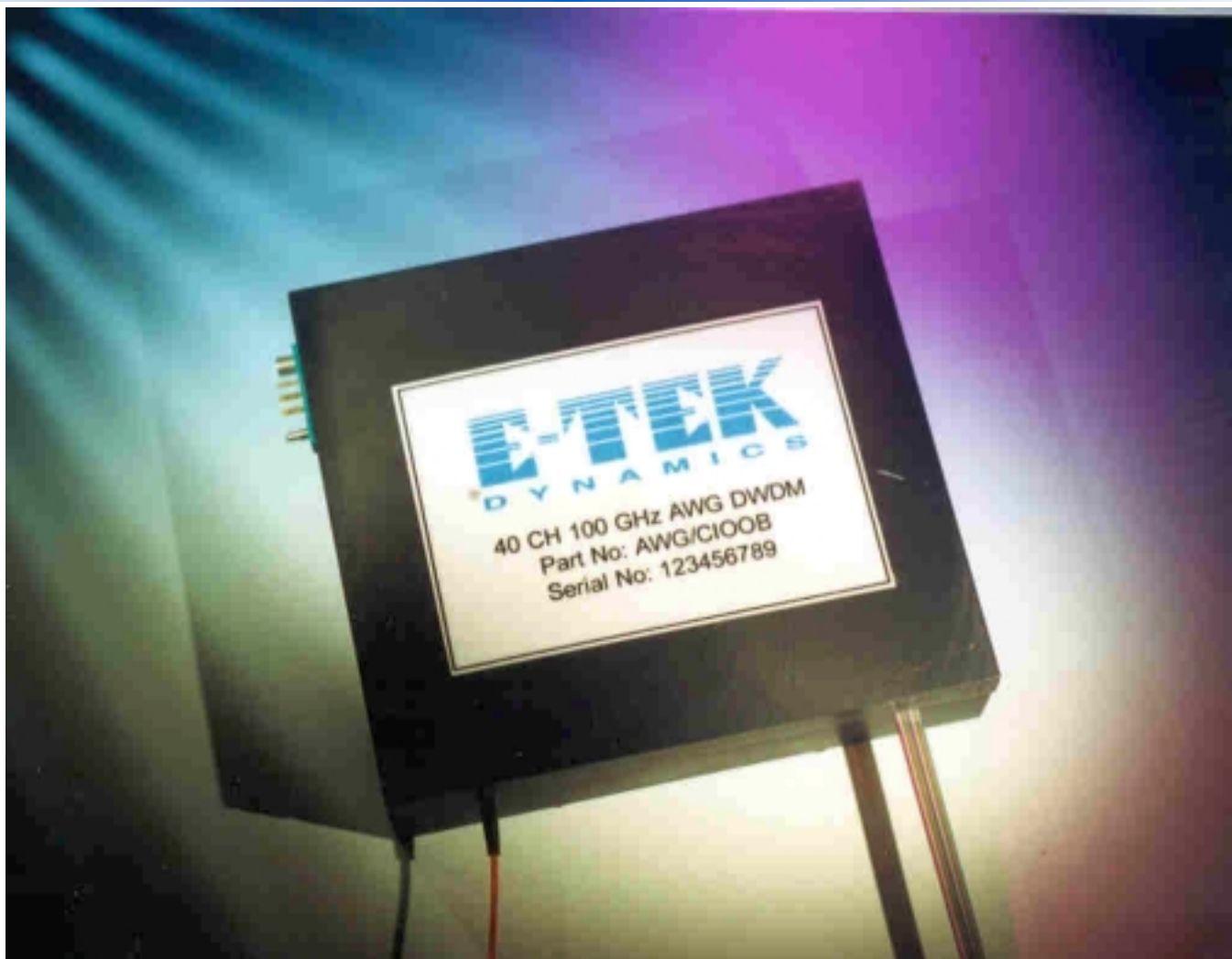


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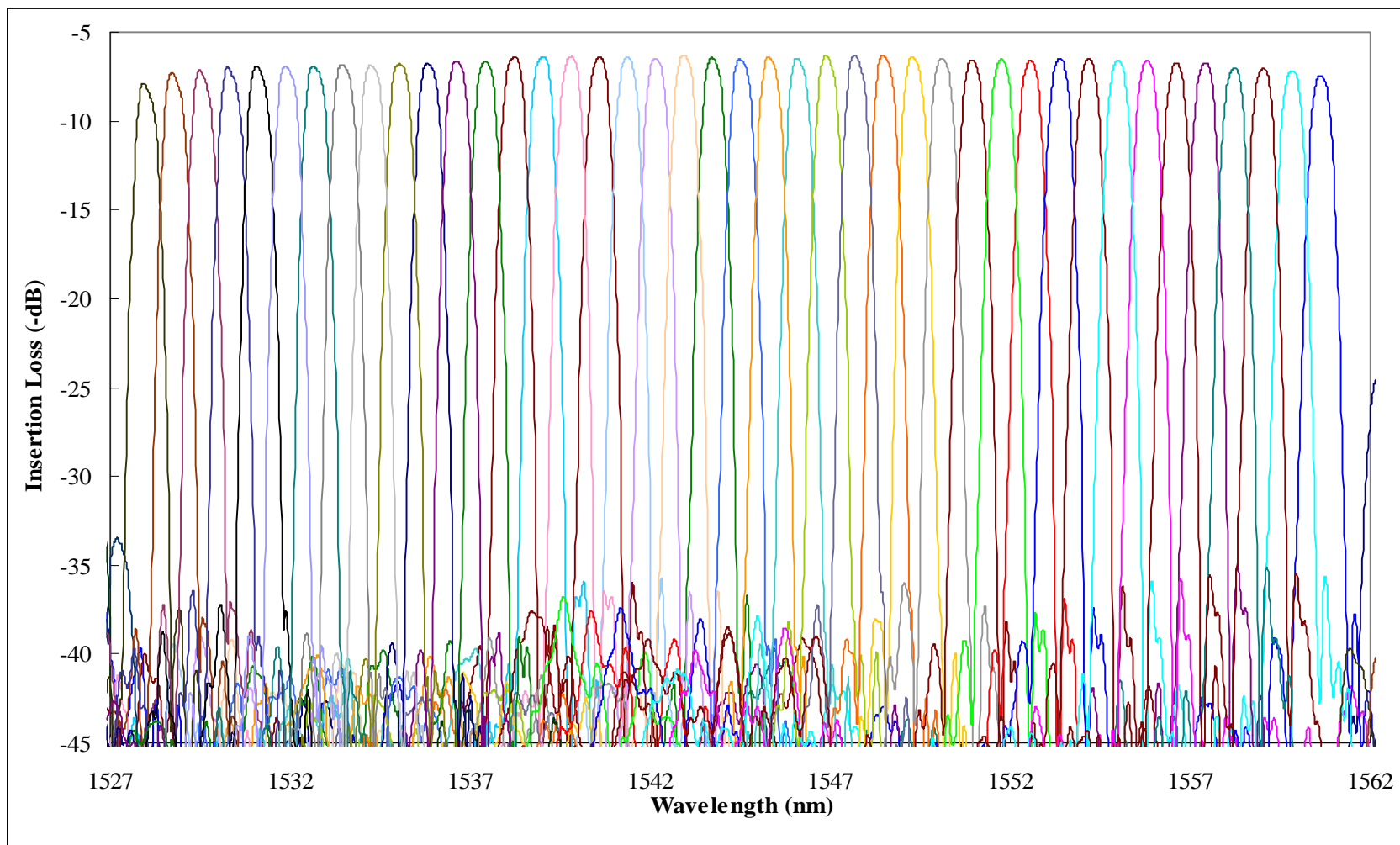
Packaged Silicon AWG



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Typical Spectrum of Packaged AWG Module



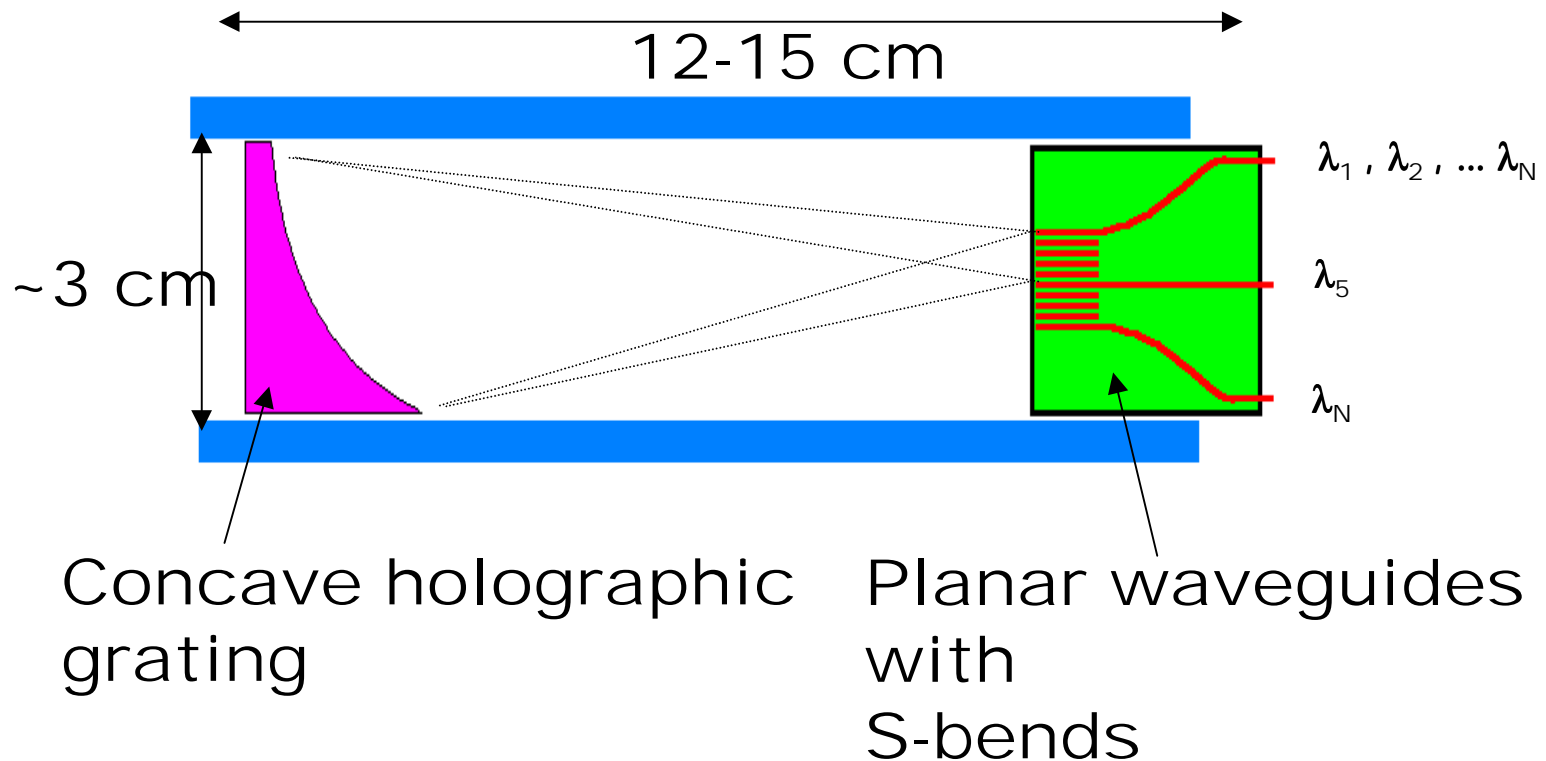
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Holographic grating DWM

Simple structure, high channel count



Holographic Grating Attributes

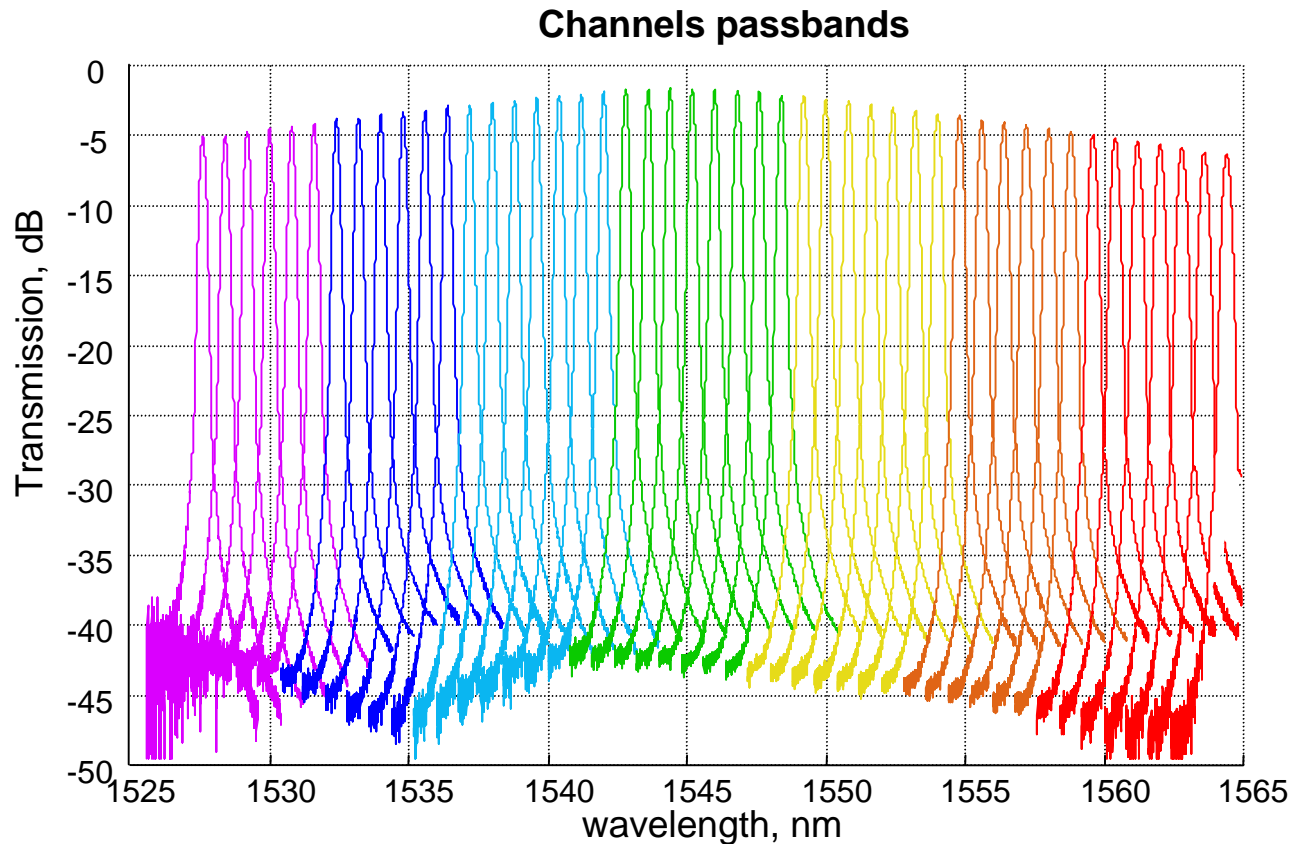
- High channel count, yet completely passive
- High isolation >40 dB
- Less developed than PAWG

Issues:

- Channel uniformity
- Passband flatness
- Polarization-dependent loss

Measured HG Response (Not Flattened)

50 channels @ 100 GHz, not flattened

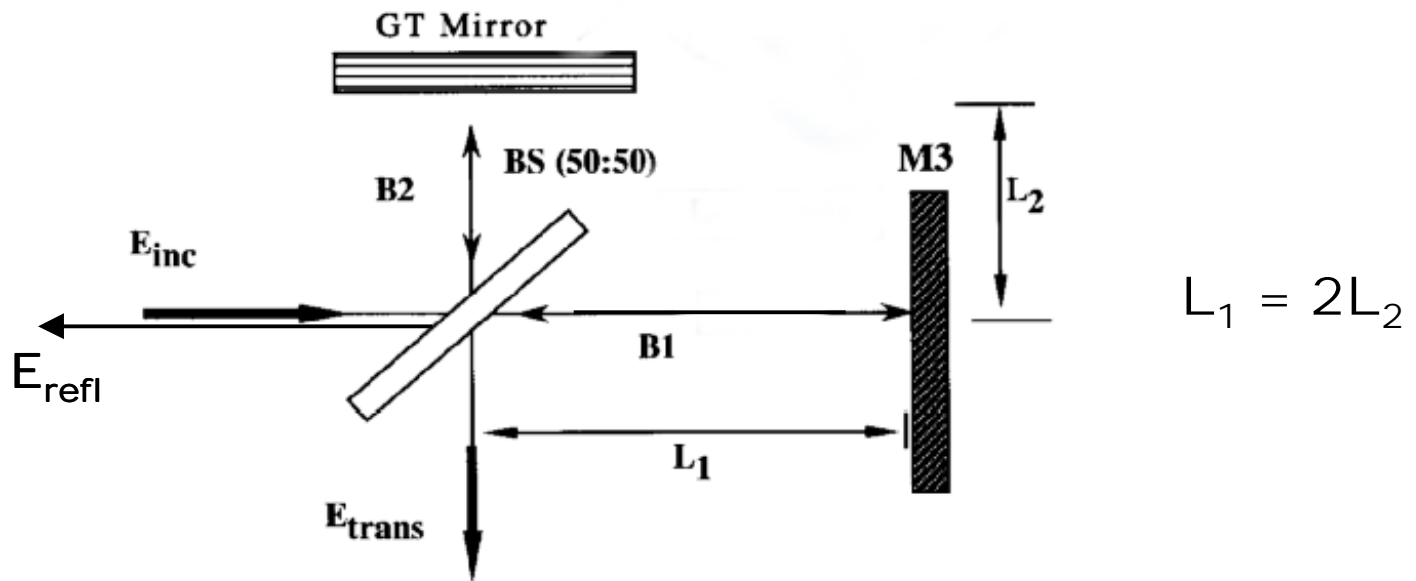


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Basic Michelson-Gires-Tournois Interleaver Structure



After Dingel and Aruga, JLT vol. 17(8), pp. 1461, 1999.

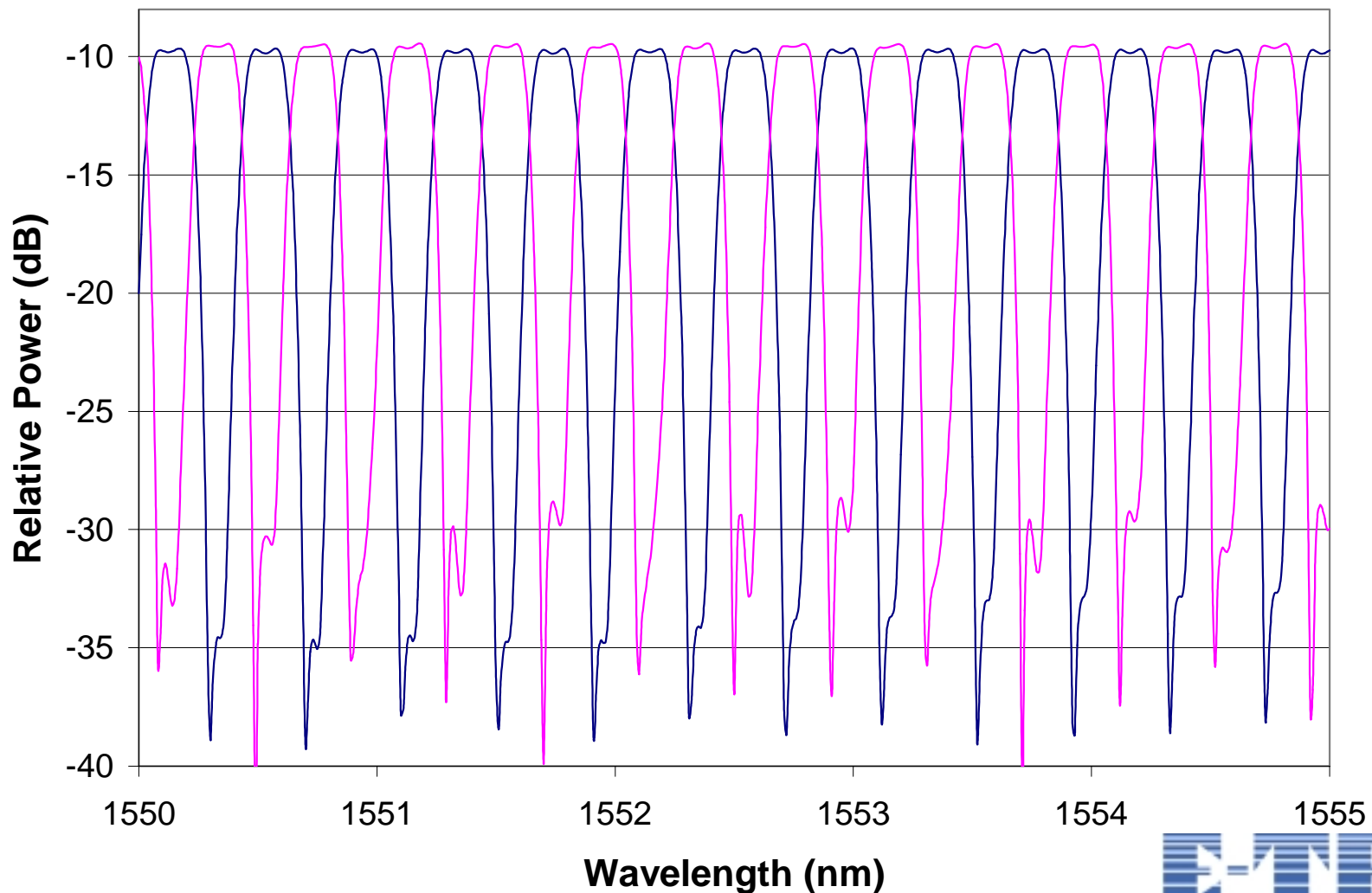
Packaged Prototype 25-GHz Interleaver



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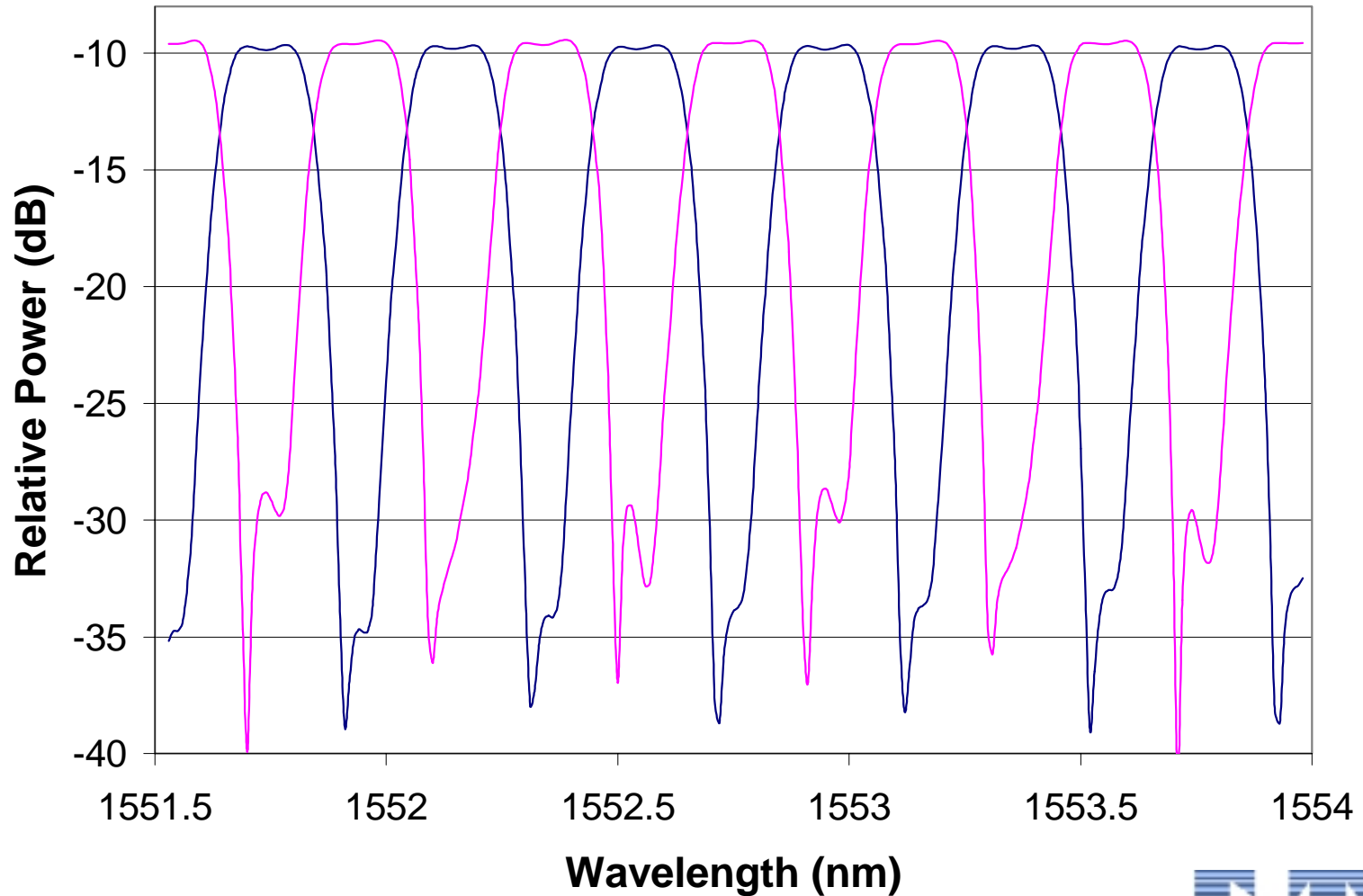
25-GHz Interleaver Characteristics



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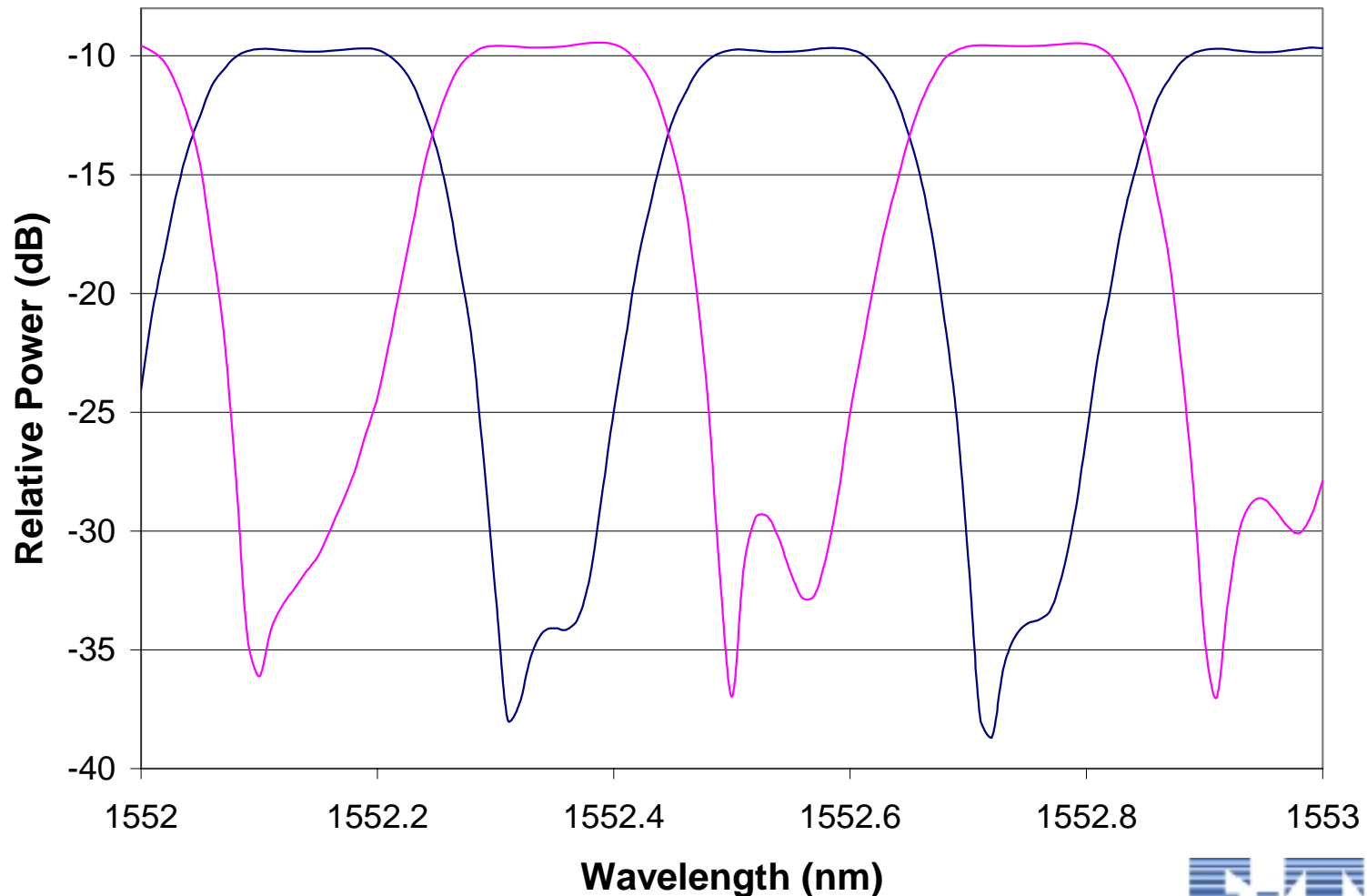


25-GHz Interleaver Characteristics



25-GHz Interleaver Characteristics

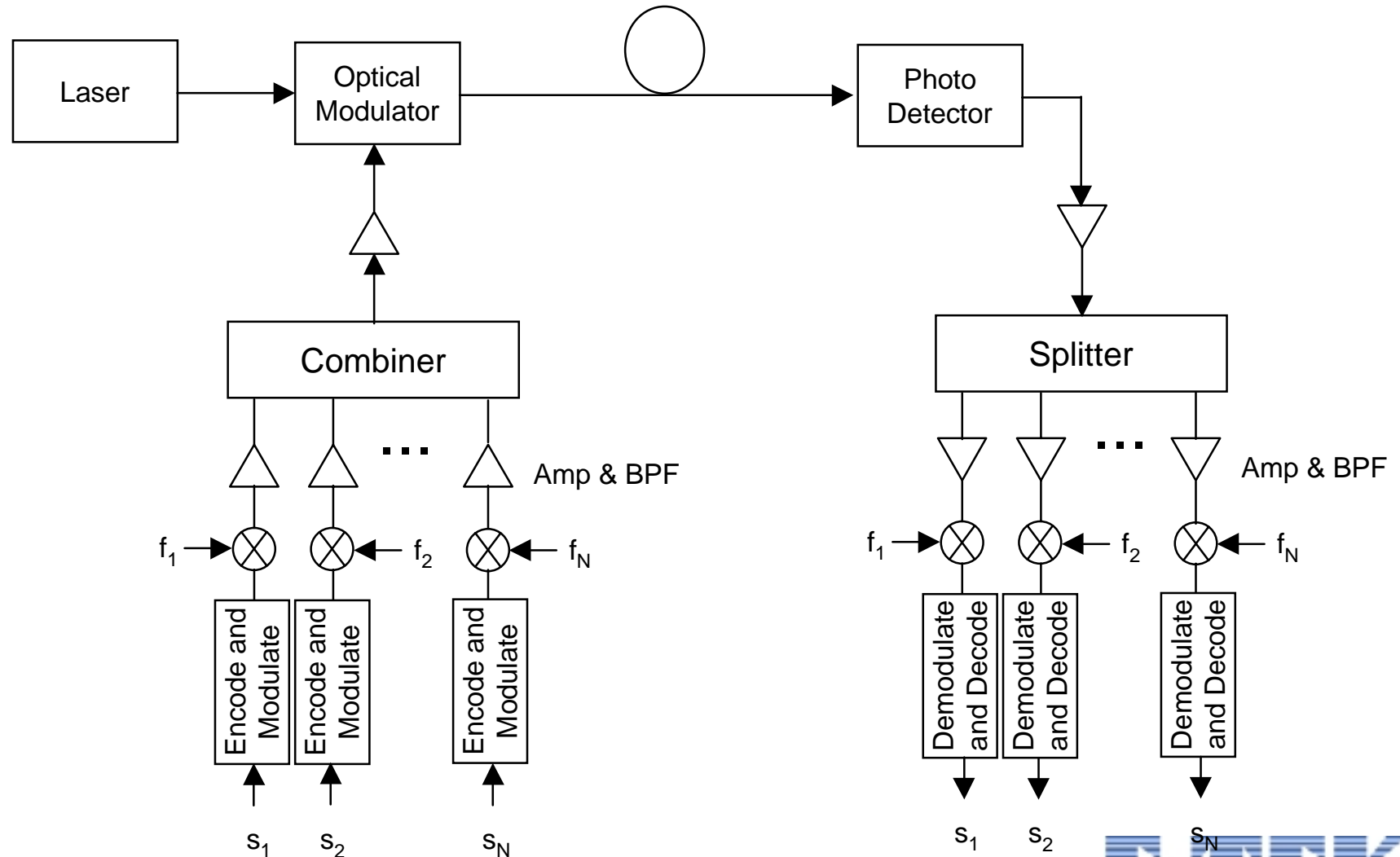
(Insertion Loss ~ 2 dB)



System Demo with Kestrel

- Using a 25-GHz interleaver and 10-Gbps optical FDM systems, a two-channel ultra-dense WDM system was demonstrated.
- BERs down to 10^{-12} were achieved.
- No BER floor observed.
- Power penalty due to interleaver was negligible.

Optical Frequency Division Multiplexing (Kestrel)

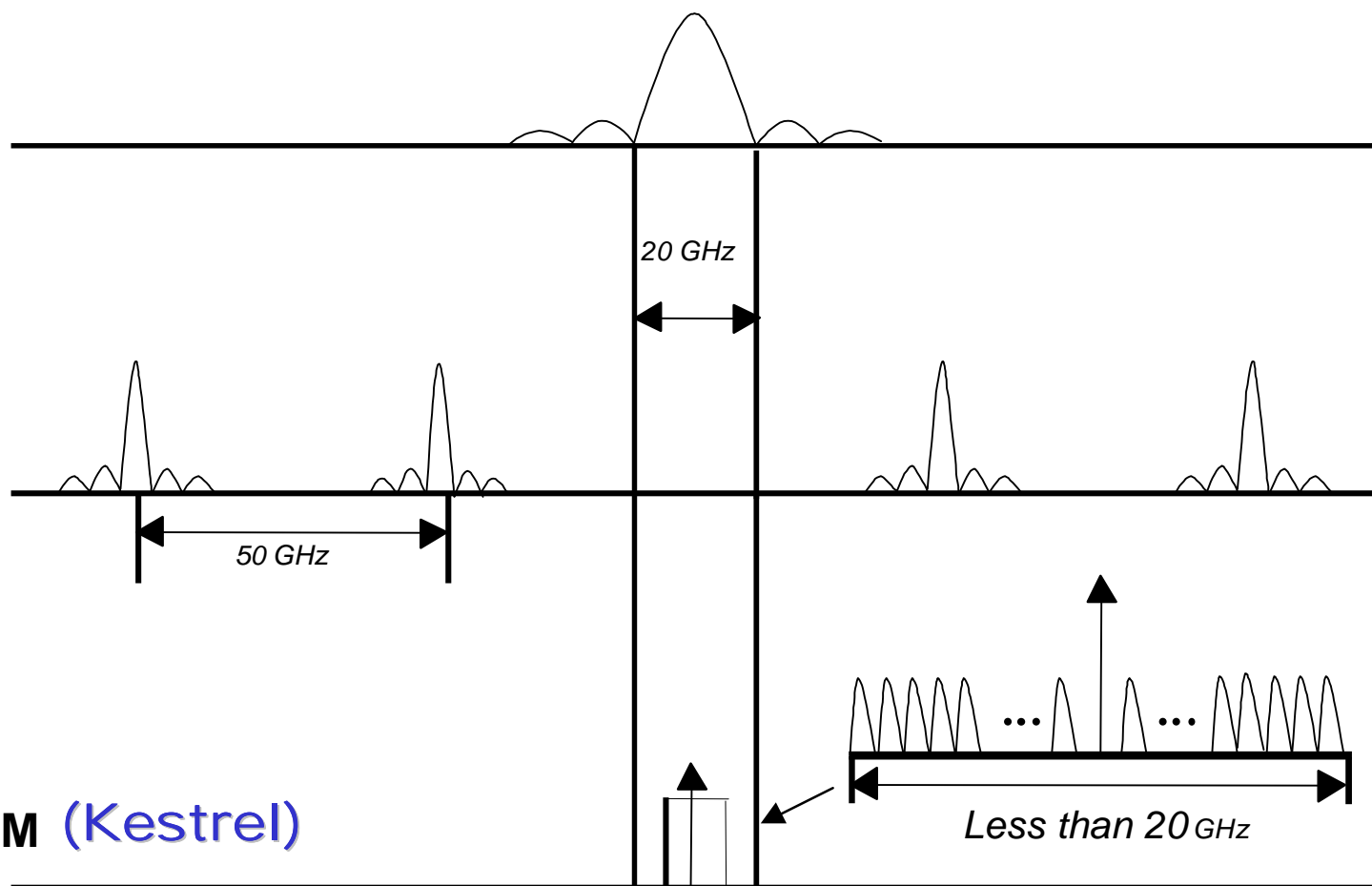


Spectra For Three Different Methods Of Transmitting 10 Gbps

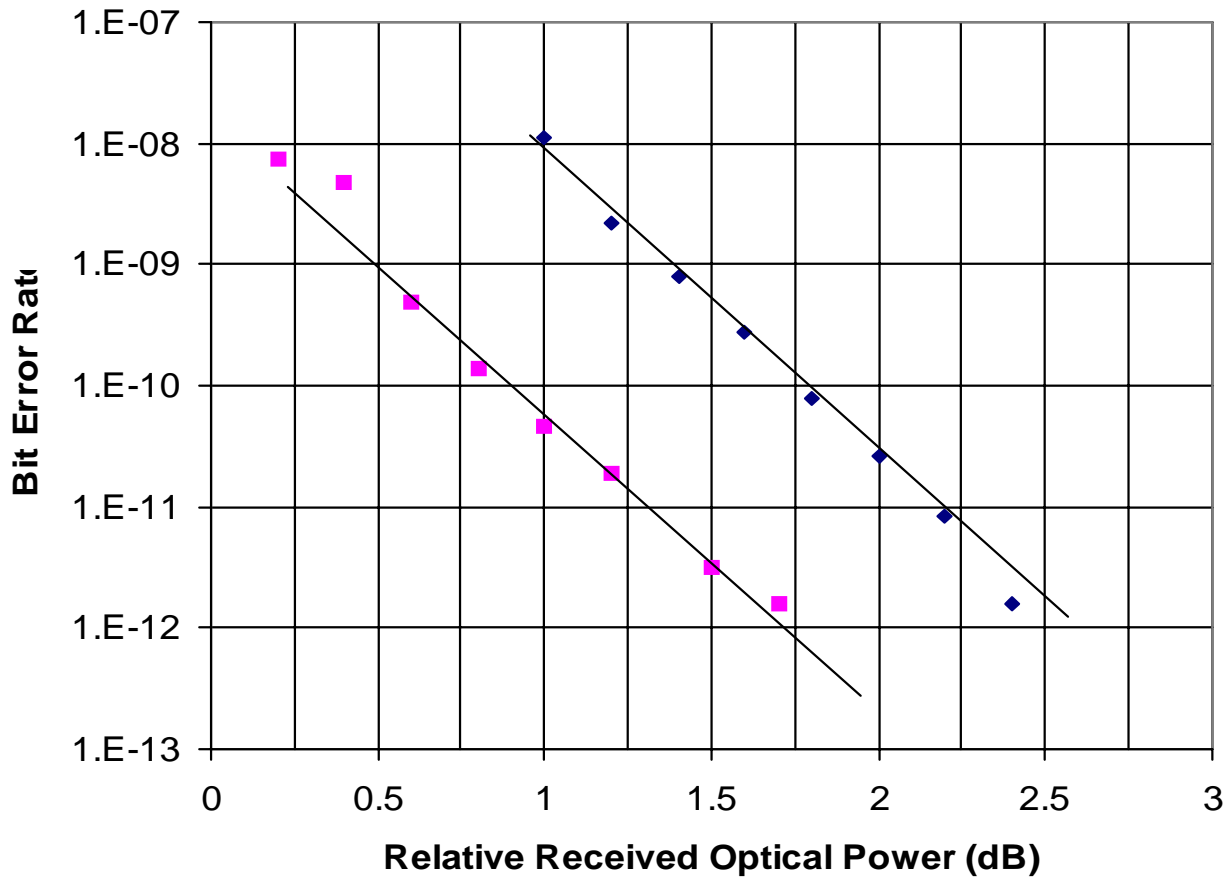
**TDM:
OC-192**

**DWDM:
4 OC-48's**

Optical FDM (Kestrel)

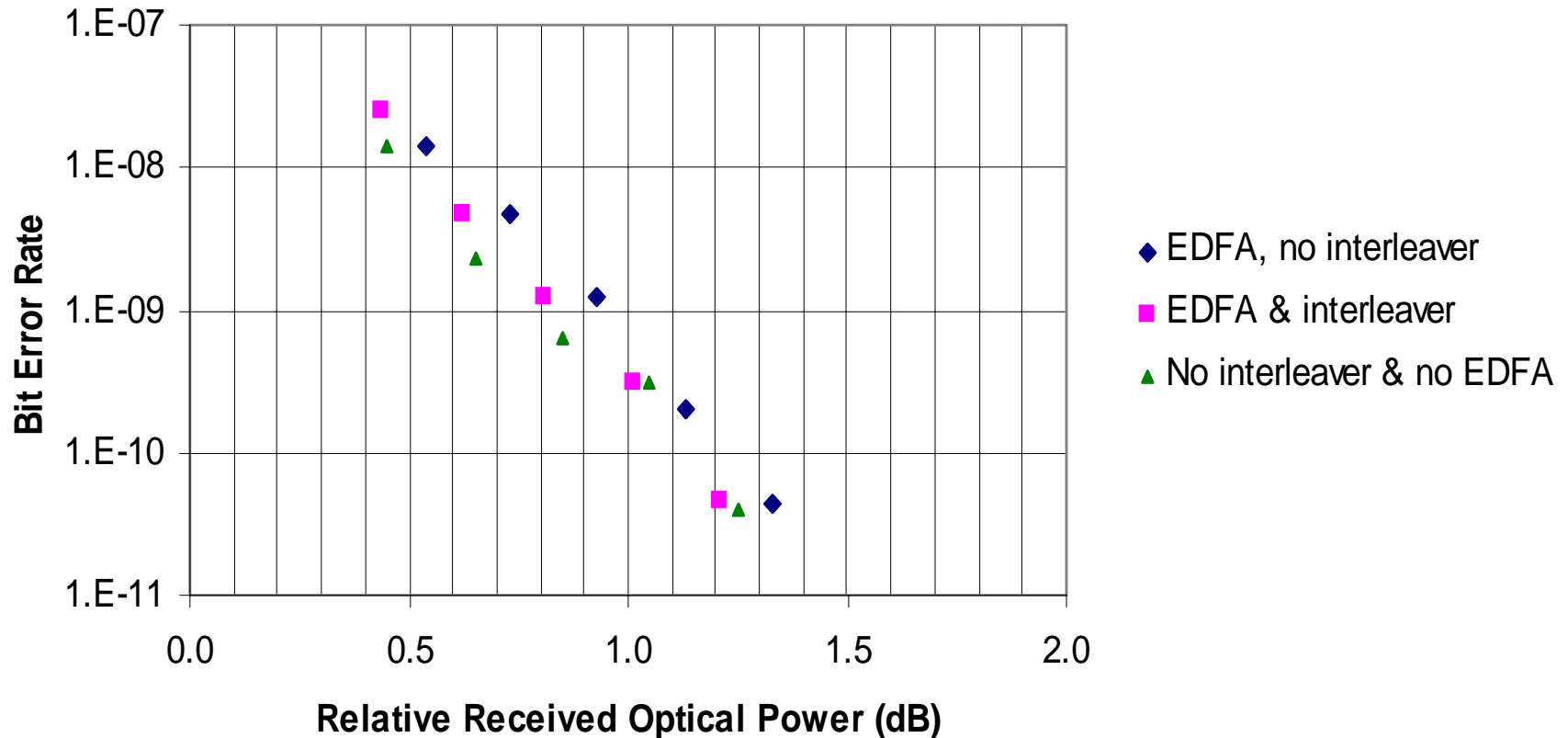


DWDM System BER



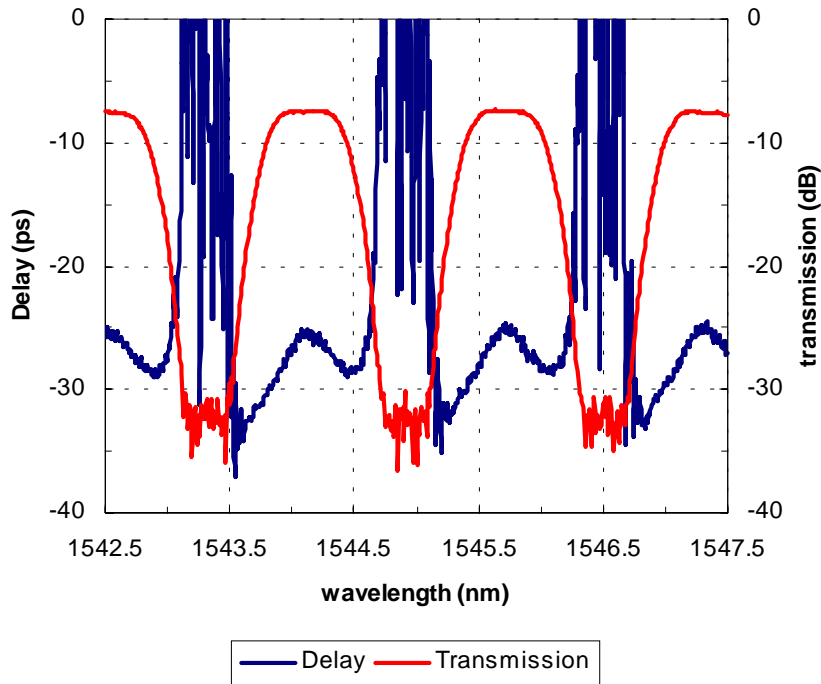
Laser frequency (THz): ■ 193.081 ◆ 193.055

Impact of Interleaver on BER

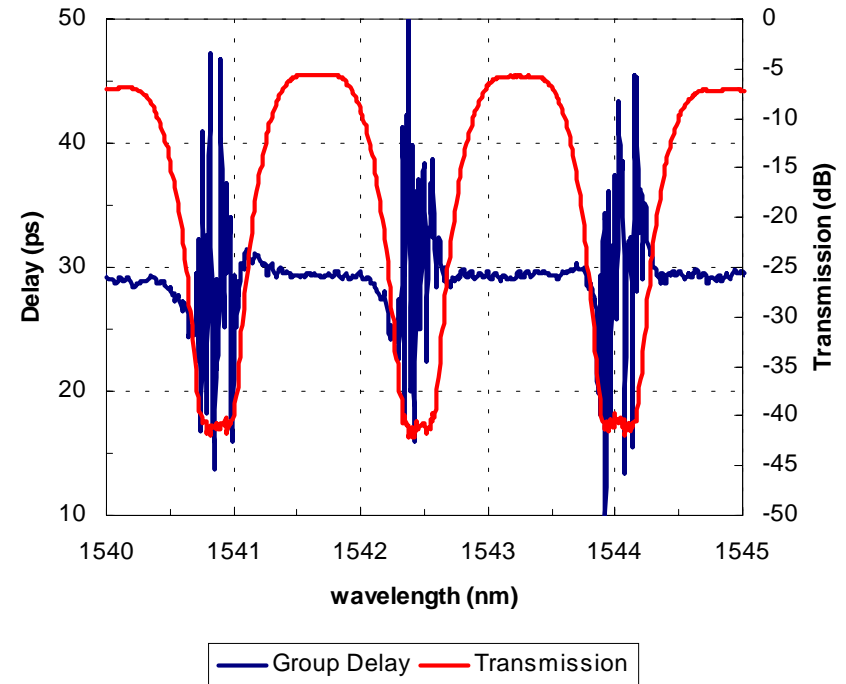


INTERLEAVER DISPERSION

Other Interleaver Dispersion Measurement



E-TEK Interleaver Dispersion Measurement



Special Thanks to Agilent Technologies: R. Fortenberry, F. Liang, A. Noorila, J. Zhang for dispersion measurement



Agilent Technologies

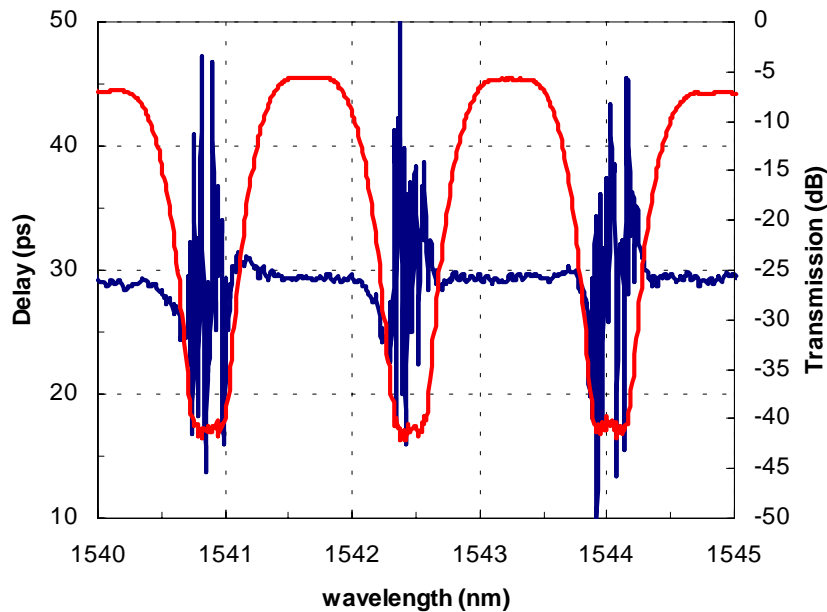
Innovating the HP Way

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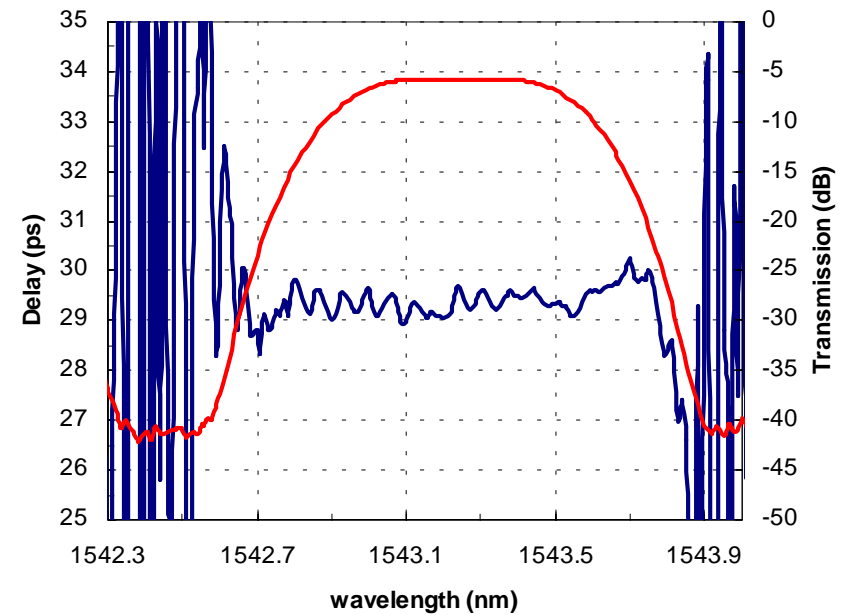
Less Than 1ps DGD

E-TEK Interleaver Dispersion Measurement



— Group Delay — Transmission

E-TEK Interleaver Dispersion Measurement



— Group Delay — Transmission

Special Thanks to Agilent Technologies: R. Fortenberry, F. Liang, A. Nooriala, J. Zhang for dispersion measurement



Agilent Technologies

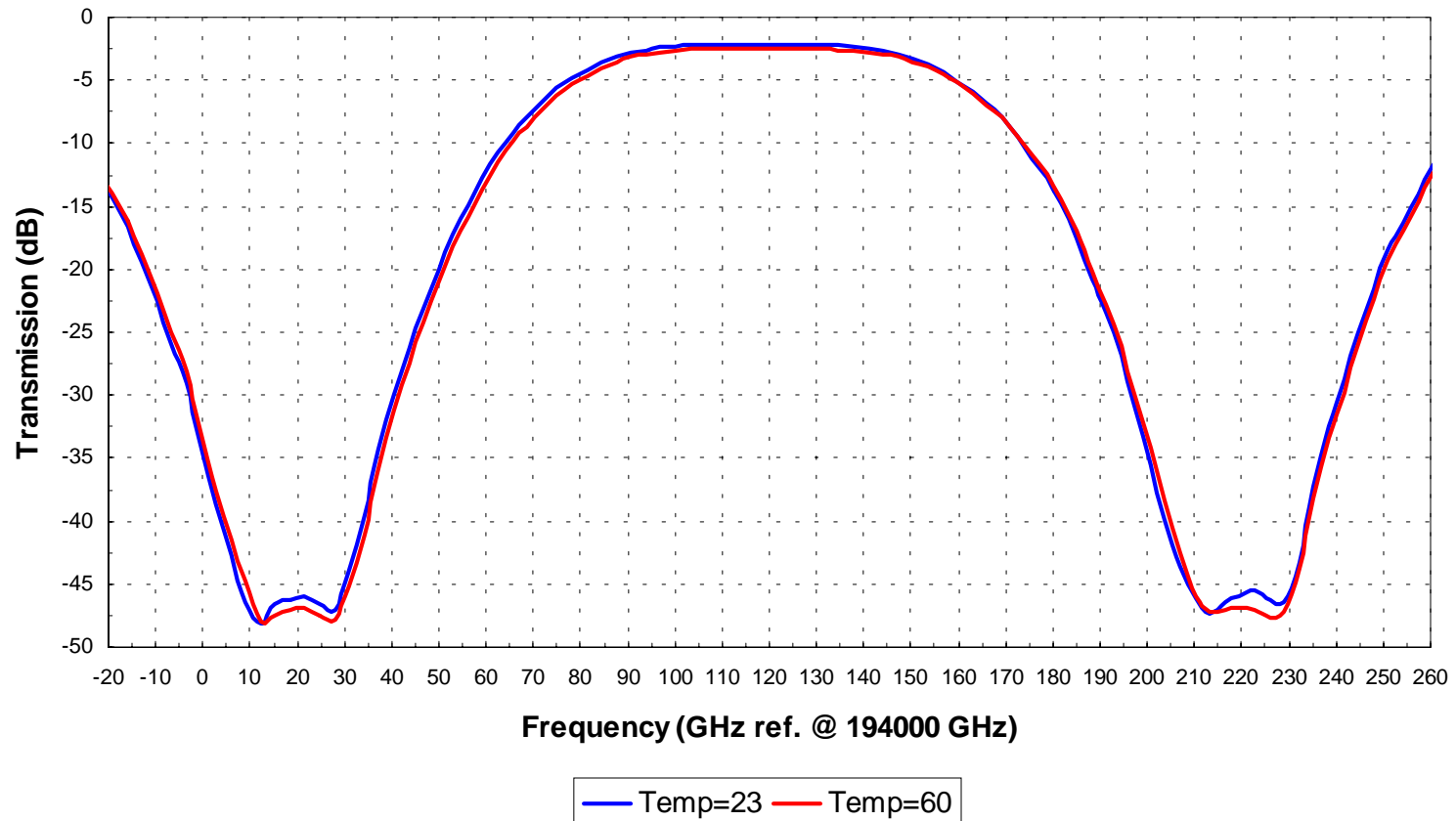
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Interleaver Temperature Dependence

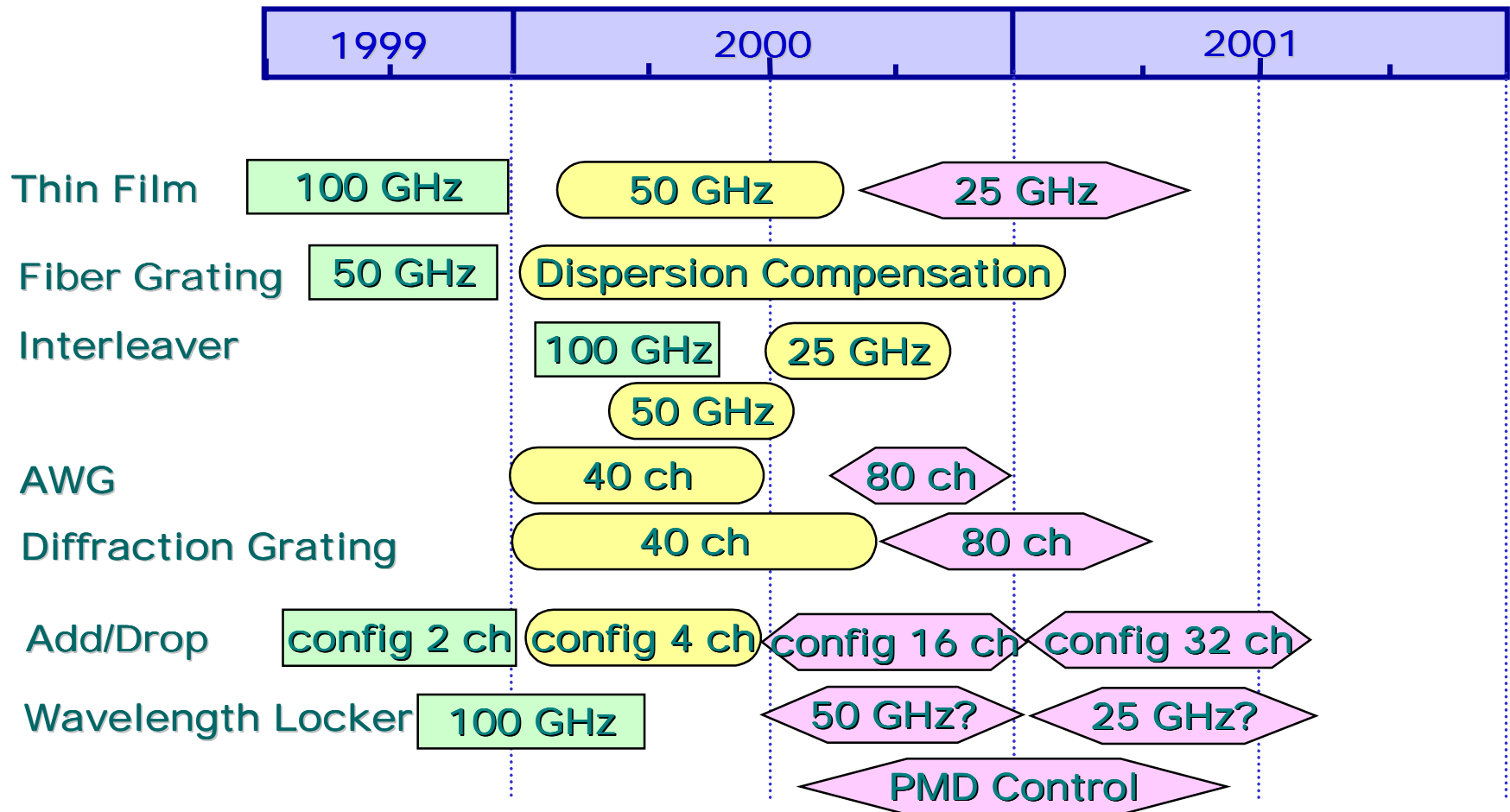
Temperature Dependent of Type II 100 GHz Interleaver



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DWDM Component Development Road Map



KEY: production development research

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OPTICAL NETWORK EVOLUTION

